Hard X-ray Telescope Progress and Development Plans

This presentation to focus on development of optics prototypes. Next FST meeting will include detailed presentation on detector development status

Agenda

Overview of program	(10 min)	R. Petre
Glass optics development	(20 min)	W. Zhang
	(10 min)	F. Christensen
Ni optics development	(40 min)	P. Gorenstein
		G. Pareschi
		S. O'Dell
Q&A	(10 min)	

Overview of Development Program

FY03

- Primary emphasis on development of two optics prototypes - Ni and glass

  Goal of prototypes is to demonstrate all key components required for fabrication, and demonstrate resolution and throughput

  Both prototypes will be evaluated for HPD, throughput at MSFC in identical setup for direct comparison

  Down-select at end FY03/start FY04 to single technology for full environmental testing

- In FY03 CdZnTe detector, low-noise electronics work largely on hold so funding can be devoted to optics prototypes

  Low-level effort will continue in detector material evaluation and low-energy threshold evaluation, largely supported through SR&T

Primary (Con-X funded) Efforts for FY03

Fabricate and evaluate 5-shell Nickel replica prototype
Fabricate and evaluate 6-shell glass replica prototype
X-ray test both prototypes using same beam/setup
Test and evaluation of low-energy detector threshold (partial support)
Support Con-X engineering studies

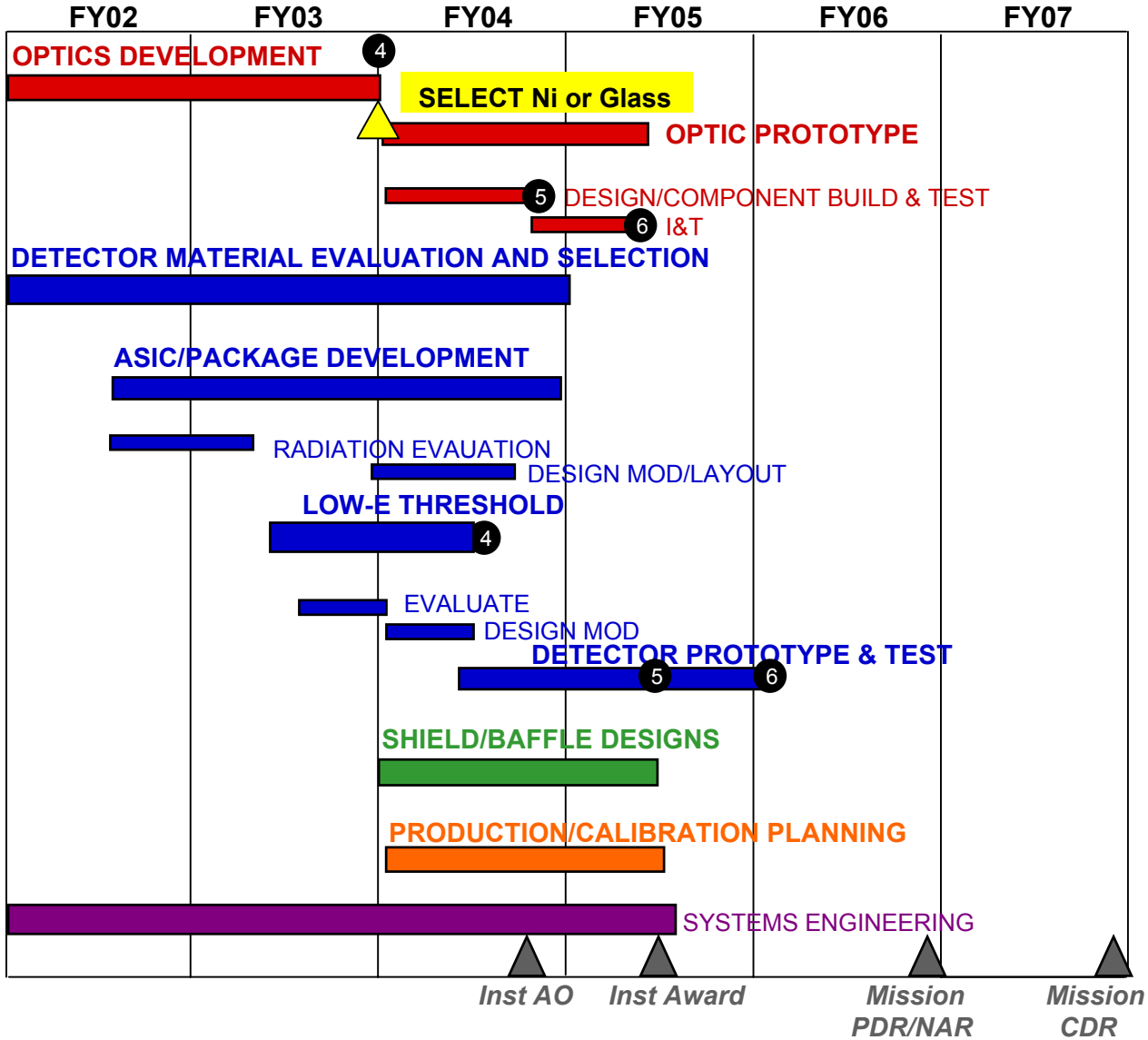
FY04 overview

Development of prototype optics module for environmental testing

Development of CdZnTe/low noise ASIC hybrid for environmental testing and performance evaluation

Instrument AO at end FY04 - will decide final optics and detector technologies for implementation

HXT Technology Roadmap w/Budget

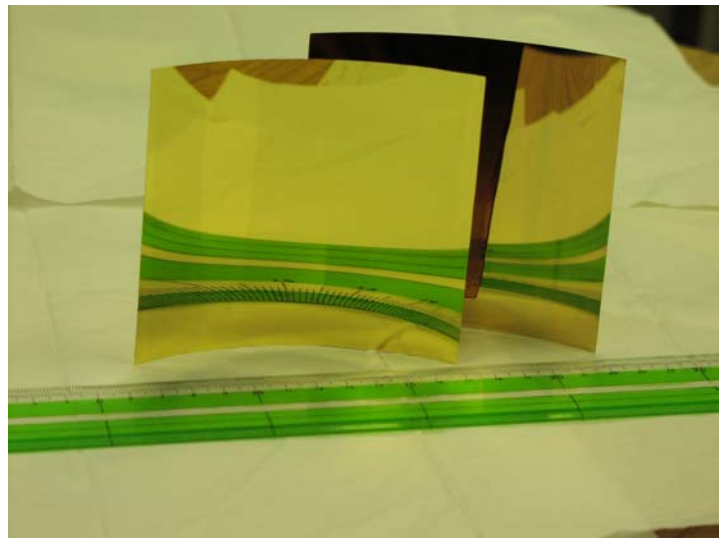


Critical Technology Milestone # Technology Readiness Level (TRL)

Segmented Glass Optics

Thin (200 – 300 μm) glass microsheet segmented into (typically) five azimuthal segments and two along the optical axis.

- Glass slumped over a forming mandrel in an oven.
- Epoxy replication reproduces the surface of a gold-coated mandrel.
- Multilayers will be deposited directly on the replicated glass (can be deposited on the mandrel and pulled off - a backup approach).



The segments are replicated as cones (conical approximation contributes 10'')

Segmented Glass

Collaboration:

Columbia University	Charles Hailey, David Windt
DSRI	Finn Christensen
GSFC	Will Zhang, Rob Petre
LLNL	Bill Craig, Todd Decker
Caltech	Fiona Harrison

Technical goals:

20’’ HPD
W/Si multilayers with response to 69 keV
0.2 mm thick glass - 82 kg/satellite (150 is requirement)
1500 cm^2 @ 40 keV (total all satellites)
1000 cm^2 @ 60 keV

Glass Replica - Primary Technical Issues

Production of replica shells with low (< 5AA rms) roughness (Good mandrels)

- •Replication mandrels used to-date (in FY02 prototype) had high roughness - replicas have 30AA rms at small length scales
- •Glass mandrels have been difficult to procure - for HXT need only cone or even cylinder

Demonstrate mounting of replica shells can achieve <60" HPD (20" goal)

- •Shells produced for FY02 prototype too rough for X-ray testing. Must repeat in FY03 prototype with smoother shells

Demonstrate direct ML deposition on replica surface

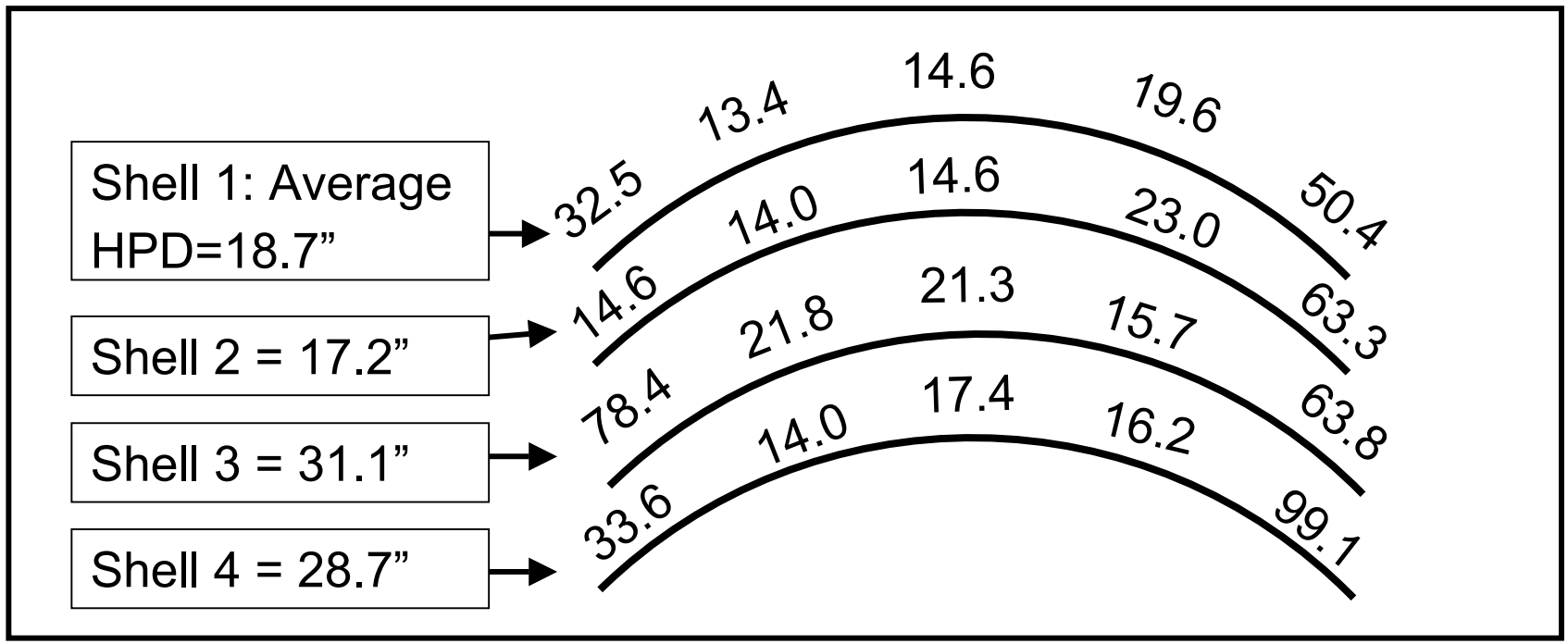
- •Damage to epoxy?

→ Many of the essential components have been demonstrated by GSFC, Columbia, and DSRI, however not in an integrated configuration

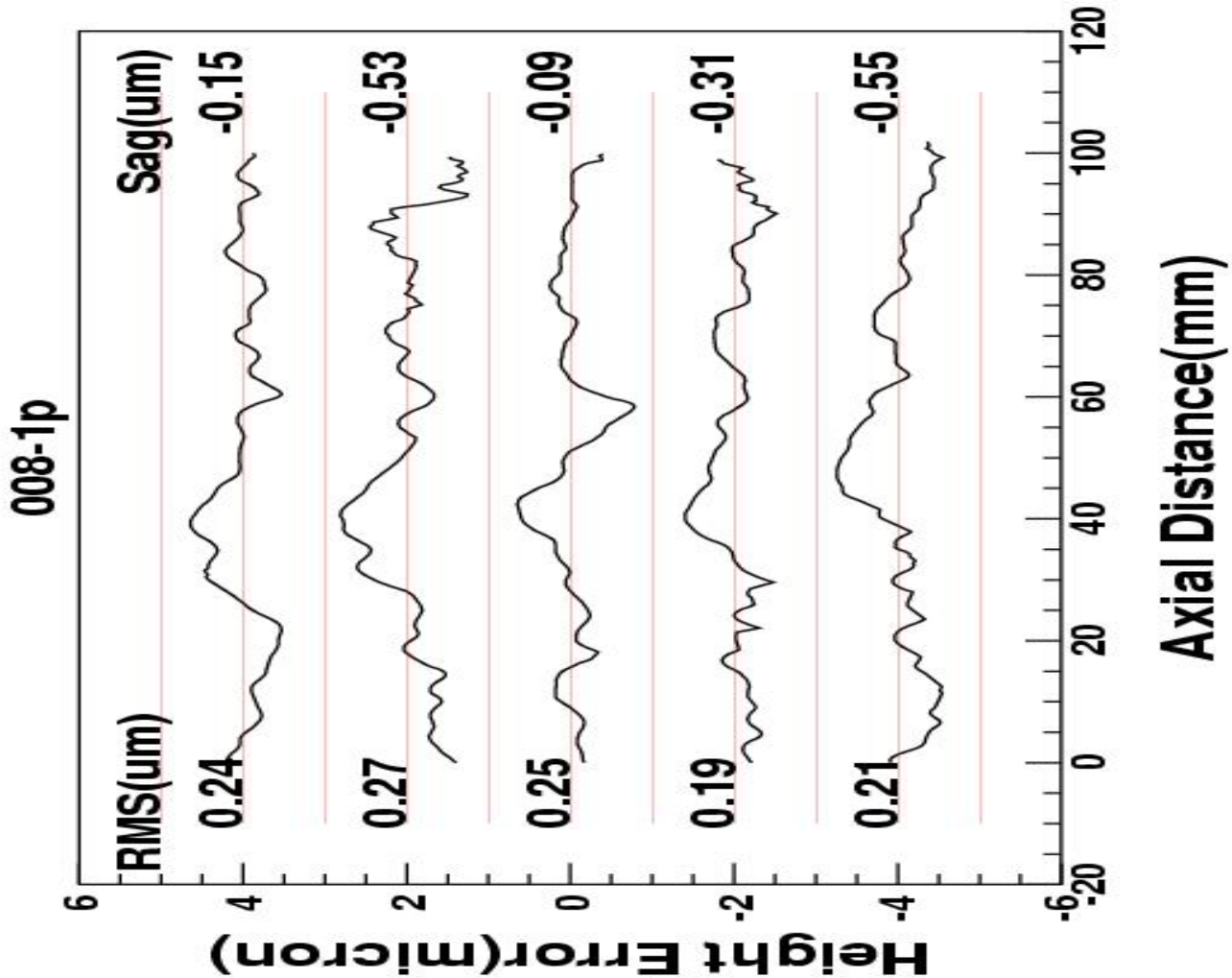
Segmented Glass Optics

GSFC epoxy replicated glass shells show excellent performance

- Axial interferometric scans, at 5 azimuthal positions, on the 4 trial shells show performance exceeding HXT goals
  - better performance at center; all half power diameter numbers, in arcseconds, are for two-reflections



Improvements in Glass Forming

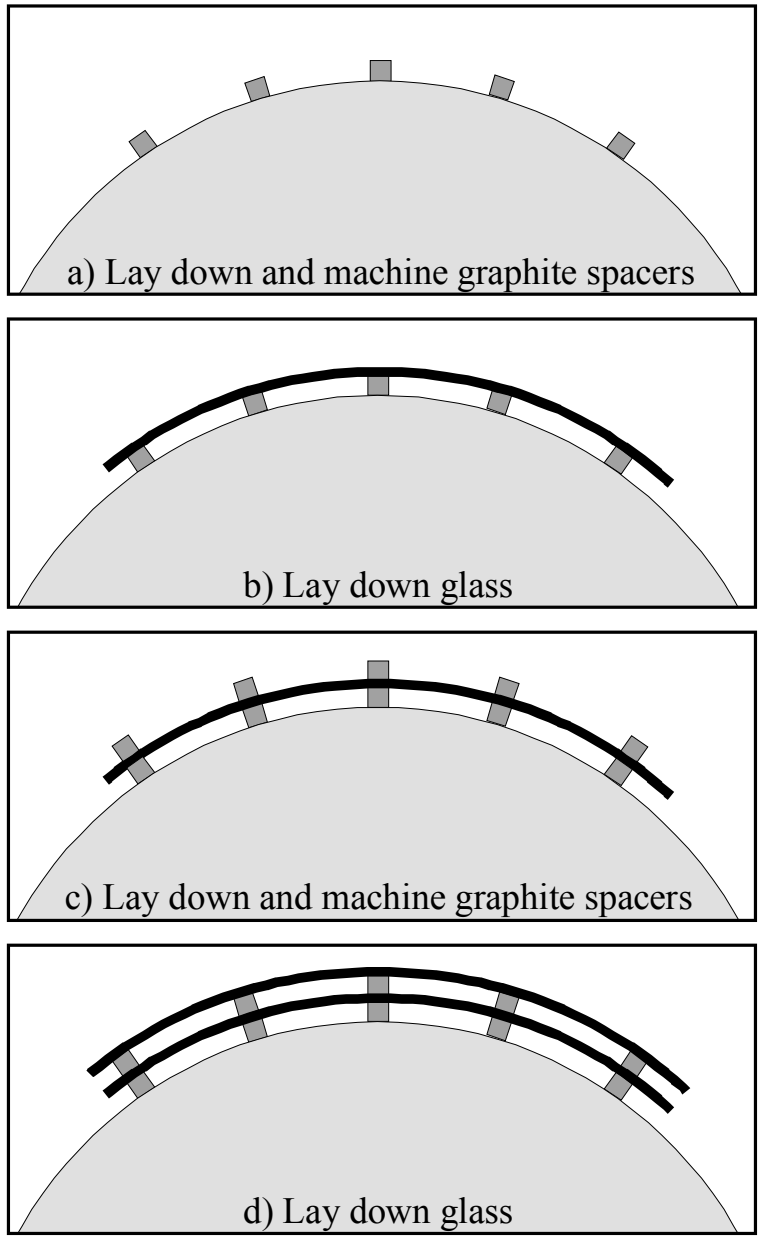


Improvements in forming at GSFC will produce glass with good (<40”) figure even without replication.

Segmented Glass Optics

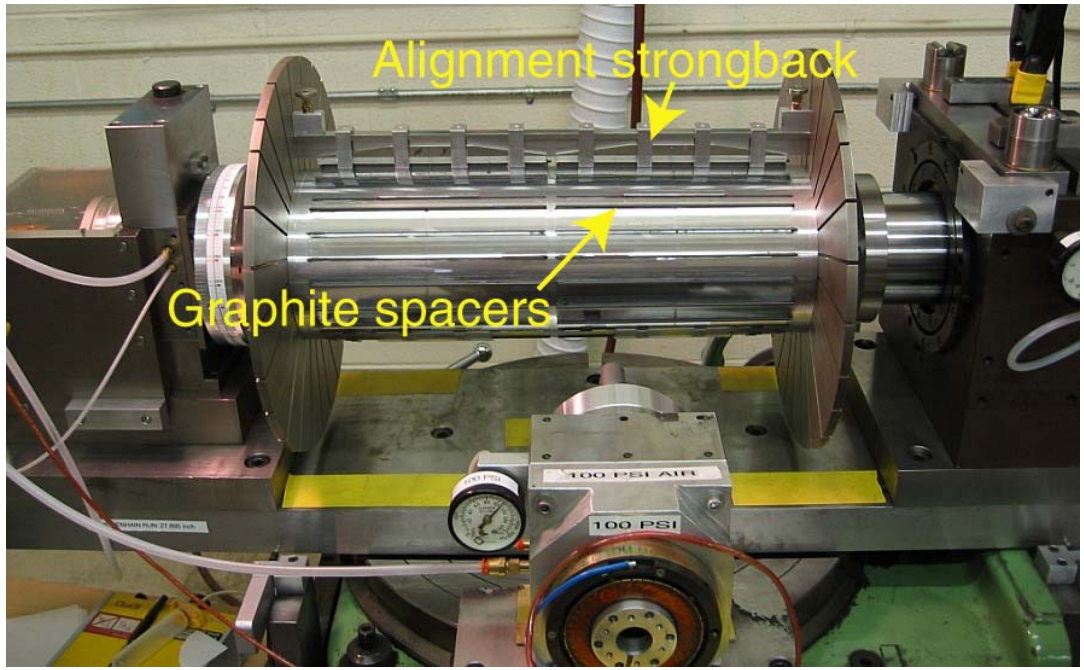
Newly-developed over-constrained mounting technique has demonstrated the ability to locate shells with precision corresponding to 5’’.

To-date has only been applied to glass with poor initial figure. Use of replica shells will demonstrate ultimate mounting accuracy



Segmented Glass Optics

Assembly machine is now operational at Colorado Precision Products



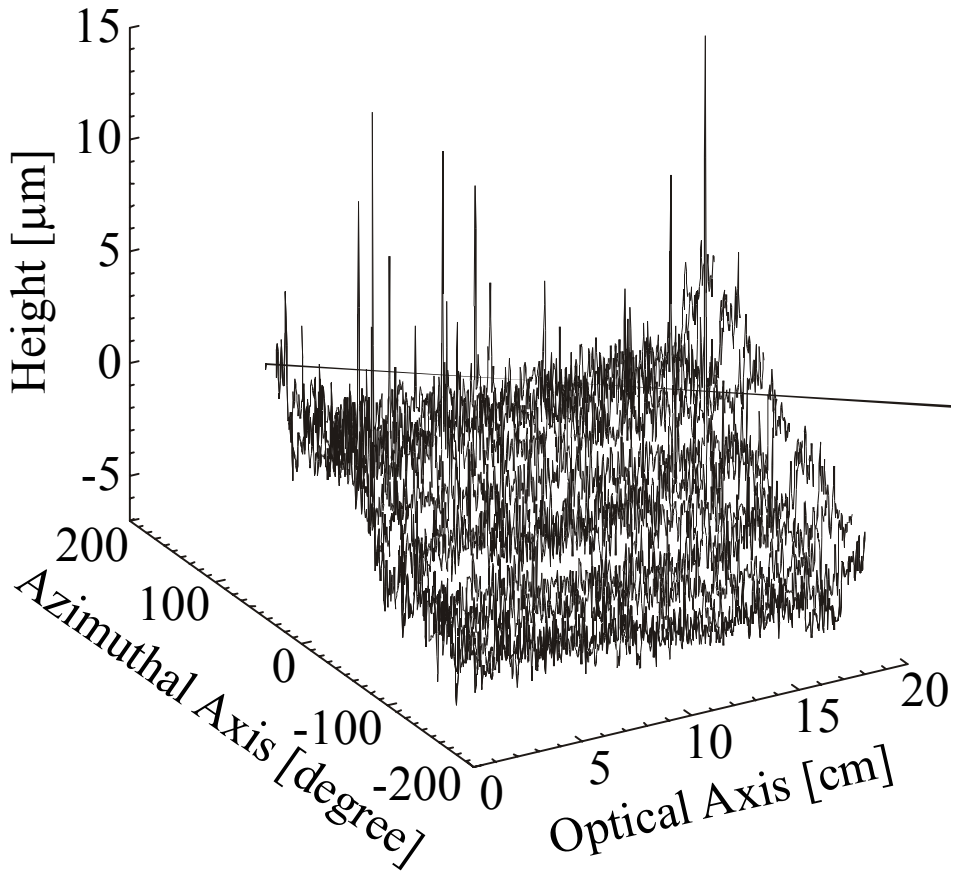
Assembly machine uses air bearing spindles and Moore tables to achieve sub-micron precision.

Glass prototype shells being assembled on the machine at CPPI

Segmented Glass Optics

Assembly machine now produces machined spacers greatly exceeding the required precision.

Axial LVDT measurements are plotted with respect to their axial position on the optic for an entire complement of machined spacers. The machined spacers have a high frequency peak to valley roughness of about 1.5 mm. The tool wear of ~0.5 mm per spacer, evident as a function of azimuth in the plot, is compensated for in the machining process.



Graphite spacers are machined to better than 3” slope error

Prototype Plans

Two prototypes:

Prototype 1 (P1) - 5 shells centered on 20 cm diameter.

- Requires a single replication mandrel
- Demonstrate ultimate resolution with high-quality mandrel, replica shells

Prototype 2 (P2) - 10 unreplicated shells centered on 7 and 40 cm diameter

- Requires no replication mandrels
- Accurate glass figure metrology before and after mounting to demonstrate mounting errors independent of radius
- Demonstrate resolution possible without replication step, with new forming process

This minimizes the number of replication mandrels required. If two can be procured according to required schedule, prototoypes will be combined.

Work Plan

Fabricate and evaluate 5-shell P1 glass replica prototype and 10-shell P2. All shells will be full-revolution and be coated with optimized W/Si.

This will be a collaboration among Columbia, GSFC, DSRI, LLNL, CIT

Subtasks:

- Fabricate epoxy-replicated glass shells -- GSFC
  - 6 forming mandrels
  - 1/2 technician
- Mount shells at CPPI - Columbia
  - Includes mounting hardware (mandrels), CPPI costs and engineering/design
- Metrology, overall science support
- Coat ML on shells
- X-ray test coated shells
- Purchase mandrels

Con-X Glass Prototype Schedule